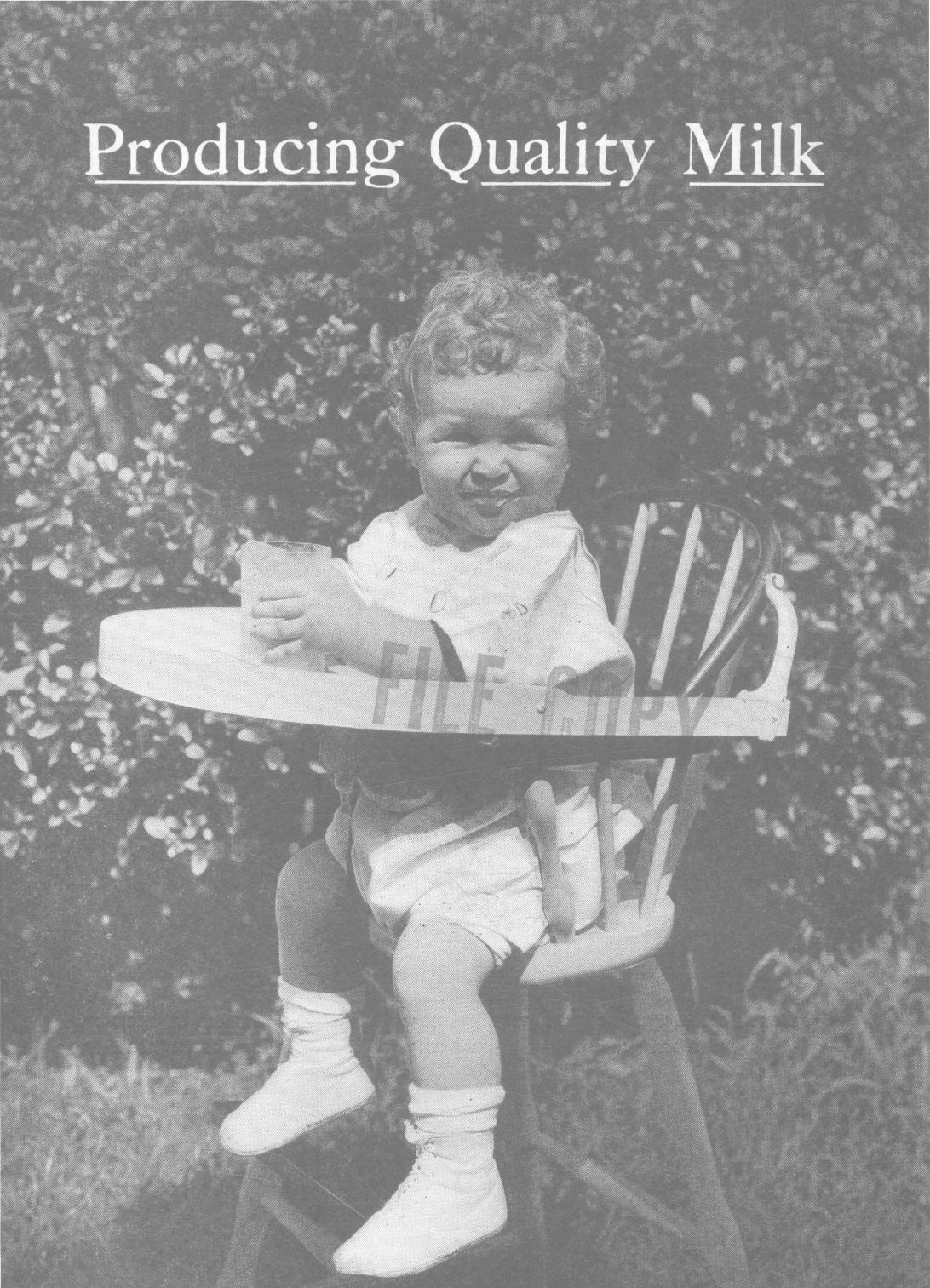
Producing Quality Milk



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Agricultural Extension Service, The Ohio State University

Foreword

THE primary purpose of milk production, from the standpoint of the cow, is to furnish nourishment for her calf; from the standpoint of the dairyman, to provide a food with which to nourish humanity. As the dairy industry developed it encouraged greater milk production through the use of better cows, and better quality milk (from the standpoint of cleanliness) through more sanitary methods of handling milk on the farm.

One of the greatest advances in dairying has been the establishment of a system for buying milk at receiving stations on a basis of fat content. In addition to encouraging the selection of high testing cows, it has practically eliminated what was once a serious problem, namely, adulteration. The greatest stimulus for clean milk production has been the establishment of commercial grades and methods of measuring quality. A further inducement for producing clean milk on the farm has recently come about through offering premiums, based chiefly on bacteria counts and sediment tests made at the receiving station.

The high value of milk as a food has always been taken for granted. It was known to be the best single food for man, but milk was milk regardless of when, how, or where it had been produced.

Some new discoveries, however, have shown that milk produced in the summer time when the cows are on pasture is quite different from milk produced by the same cows in the winter. They also show that the quality of the roughage influences the value of the milk as a food, just as it does the amount of milk produced. These and other revelations brought forth in recent years have made it necessary, in any discussion of milk production, to include the food value of milk and how it is affected by various influences. After satisfactory methods have been devised for the determination of the food value, this will be one of the factors taken into consideration in grading it in the future.

The welfare of the whole dairy industry is intimately bound up with the quality of milk produced on our farms. Perhaps the average dairyman does not realize to what extent the quality of our market milk, cheese, butter, ice cream, and condensed and powdered milk is dependent on the individual effort he puts forth to produce what is called quality milk.

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Factors Determining the Value of Any Food

NUTRIENTS

A food is a substance which may be taken into the body, suitably prepared, and used to yield energy, to build body tissue, and to regulate the body processes. Energy is required for everything the body does; tissues are constantly being worn out and replaced, even in the mature body, and certain regulators, like minerals and vitamins, are necessary for life. The various constituents of a food that are used for these purposes are called nutrients.

Protein.—Proteins are the chief organic constituents of the vital parts of all plant and animal cells. They are necessary for body maintenance and growth. Lean meat and egg white are common examples of protein material. In digestion, proteins are split up into their "building stones' or amino acids, of which twenty or twenty-one are known. Some proteins yield all or nearly all the amino acids; some, like that in corn, are lacking in one or more of the essential ones. It is, therefore, the amino acid content that determines the real value of any protein.

Carbohydrates.—These are widely distributed in foods and are the principal source of energy. Sugar and starch are common examples of carbohydrates. The animal body contains but a small amount of carbohydrate material, whereas a considerable portion of plants consists of carbohydrates.

Fat.—The fats are also widely distributed in foods. Their general appearance and properties are well known. Like the carbohydrates, the fats serve chiefly as a source of energy.

Ash or Mineral Matter.—The nutrients thus far considered are organic in nature—that is, they are compounds of carbon and are destroyed by heat. The material remaining after a food is burned is called the ash, inorganic matter, mineral matter, or salts. While it constitutes only a small portion of the original food, it is of vital importance. In it are contained the calcium and phosphorus used in bone formation, the iron and copper used in blood building, and iodine that is so essential for normal development. Other essential inorganic substances are manganese, potassium, sodium, sulfur, chlorine, magnesium, fluorine, and silicon. Since the protein, fats, and carbohydrates furnish at the most five or six of the fifteen or sixteen elements found in the body, the importance of the inorganic portion of the food becomes apparent.

Vitamins.—While no definite chemical description of the vitamins, except vitamin C, can yet be made, their importance will be realized because the omission of any known one of them from the human diet will result in serious

disturbances or even death. Six vitamins are now generally recognized. For convenience they have been designated by letters.

Vitamin A is often called the anti-ophthalmic vitamin, because the most marked symptom due to its absence from the diet is ophthalmia, an eye infection, which may eventually result in blindness. It is also essential for growth, general well-being, and successful reproduction. This vitamin is fairly resistant to heat.

Vitamin B complex is the term now applied to what was formerly thought to be a single substance. Recently, at least two distinct factors have been found to comprise the former vitamin B. These have been designated vitamin B (B_1) and vitamin G (B_2). Whenever the term vitamin B complex is used it means that the composite effect of vitamins B and G is being considered together.

Absence of vitamin B, or the anti-neuritic vitamin, from the diet results in loss of appetite, accompanied by a rapid loss of weight. If death is long delayed, paralytic spasms occur. This vitamin prevents the disease known as beriberi in man and is probably concerned with lactation. It is rather easily destroyed by heat.

When vitamin G, or the anti-pellagric vitamin, is absent from the diet, growth is retarded, the eyes and mouth become sore, and eventually skin lesions appear on various parts of the body. This disease in rats closely resembles human pellagra. Vitamin G is very resistant to heat.

Lack of vitamin C in the diet produces in man and a few other species the disease known as scurvy, consequently this factor is commonly called the anti-scorbutic vitamin. This disease is characterized by soreness and stiffness in the joints, hemorrhage, soreness of the gums, loosening of the teeth, and fragile bones. It was formerly quite prevalent in babies and in those adults not having access to fresh foods, particularly fruits. Vitamin C is easily destroyed by heat.

Vitamin D is perhaps the most important of the vitamins, because it is difficult to supply an adequate amount through the use of natural foods. It is concerned with the assimilation of calcium and phosphorus, the two elements so essential for proper bone and tooth formation. Rickets is caused by a lack of vitamin D; this factor is therefore called the anti-rachitic vitamin. It is also essential for growth. Vitamin D is quite stable.

Vitamin E is the anti-sterility vitamin, so called because it is concerned with reproduction. Animals deprived of vitamin E may become pregnant, but the young are reabsorbed and not born. This vitamin is relatively stable.

The effect of feeds on the vitamin content of milk is given on page 6.

Factors Other Than Nutrients

In addition to the nutrients contained in any food, certain other factors are taken into consideration by the consumer. In recent years almost every article of food has been graded according to size, color, or other factors. Flavor is a factor of considerable importance. The consumer is interested in the flavor of oranges and apples as much as in any of their other characteristics, even though flavor may be of less importance from a nutritional stand-

point. The condition of the food is also of prime importance to the consumer. No buyer would consider partially decayed or visibly unclean food.

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Factors Determining the Value of Milk

The Composition of Milk

The average composition of milk has been determined by making large numbers of analyses. Table 1 shows its composition as given in "Feeds and Feeding," 20th edition, by Morrison:

Table 1.—*The Chemical Composition of Milk*

	Per cent
Water	87.2
Protein	3.5
Fat	3.7
Lactose (carbohydrate)	4.9
Ash (minerals)	0.7
	100.0

Casein is the principal protein of milk, making up about 86 per cent of the total protein present. The other important protein of milk is lactalbumin, or albumin. Both casein and lactalbumin have been shown to have excellent nutritional value.

The fat in milk is a very complex substance, but its effect when consumed is the same as that of any other animal fat. Its chief function as a food is to furnish energy and the fat-soluble vitamins.

Lactose or milk sugar is the other constituent of milk used essentially as a source of energy, and has other favorable effects upon the body.

Of the many mineral elements found in milk, calcium and phosphorus are the most important. Milk is the best and most economical source of calcium (lime) of any natural food. It also furnishes a generous supply of phosphorus. Since calcium and phosphorus are so important in skeletal development, the value of milk for infants becomes very apparent. Not only are calcium and phosphorus present in considerable quantity, but they are readily available to the body.

Milk contains but small amounts of iron and copper, two elements found recently to be essential for blood formation. Consequently, young animals kept on an exclusive milk diet for too long a time may develop nutritional anemia. Another element found in the ash of most milk is iodine. This substance is now known to be vitally concerned with various body processes, and the amount present in milk may prove to be of considerable importance.

The producer and the consumer of milk usually think the fat of milk is the important constituent. Fat determines the amount of the producer's milk check; in the case of the consumer, it indicates the amount of cream to be expected. As a matter of fact, however, the other nutrients in milk, particularly the protein and the minerals, are of equal importance.

Chemical Composition Varies With the Breed.—The chemical composition of milk from different breeds of cattle, and even from cows of the same breed, varies considerably. It is well known that a difference in fat content exists in milk from the various breeds of cows. That other differences in composition exist will be seen from the following table.

TABLE 2.—*Composition of Milk from Different Breeds of Dairy Cattle*
From University of Illinois Agr. Exp. Sta. Bul. 325—1929.

	Water per cent	Fat per cent	Protein per cent	Lactose per cent	Ash per cent
Ayrshire	86.89	4.14	3.58	4.69	0.68
Holstein	87.50	3.55	3.42	4.86	0.68
Guernsey	85.13	5.19	4.02	4.91	0.74
Jersey	85.31	5.18	3.86	4.94	0.70

Table 3 gives the average fat content of all the cows officially tested by the different dairy breed associations in this country up to 1935.

TABLE 3.—*Butterfat of Milk from Different Breeds of Cattle*

Breed	No. of Records	Butterfat Per cent
*Ayrshire	19,447	4.04
Brown Swiss	995	4.00
Guernsey	42,363	4.97
Holstein	35,919	3.40
**Jersey	39,800	5.35

* Ayrshire herd test records, 1926-1934 inclusive. ** Approximate number of records.

Effect of Feed on the Chemical Composition of Milk.—It is practically impossible to change the chemical composition of milk permanently through feeding. The fat content of milk has been increased temporarily by feeding large quantities of fat, but the butterfat soon dropped to its normal percentage. Recent work has shown that when 8 ounces or more of cod liver oil or fish oil are fed experimentally, the fat percentage is decreased. The proteins of milk have shown no perceptible change when rations furnishing exceedingly high or exceedingly low amounts of protein have been fed. The only chemical inorganic element of milk that has been successfully varied through feeding is iodine.

Effect of Feed on the Vitamin Content of Milk.—While a definite value as to the vitamin content of raw milk is very often given, it is doubtful if such a statement presents a true picture. The vitamin content of raw milk is variable, depending chiefly on the kind and quality of the feed given and possibly on sunlight.

Milk from cows that are well fed is usually rich in vitamin A. However, the amount of vitamin A in milk can readily be changed by changing the feed of the cow. If all the green roughage and yellow corn are removed from the ration, the milk produced becomes deficient in this factor. Milk produced by cows on pasture is rich in vitamin A.

Most investigations have shown that the vitamin B complex is affected by the amount of vitamin B contained in the various feeds of the ration, but one group of workers claims that the cow can manufacture her own vitamin B complex. This is accomplished by the action of bacteria in the paunch. This does not mean, however, that the extent of the bacterial action may not

be influenced by the nature of the feed. As a rule, milk contains only a fair amount of the vitamin B complex.

Since separation of the vitamin B complex into vitamins B (B_1) and G (B_2), it has been shown that while vitamin B (B_1) is but little affected by feed, vitamin G (B_2) may be materially influenced in this way. Milk may be considered a fair source of B (B_1) and an excellent source of G (B_2).

Raw milk is a fair source of vitamin C. Until recently, most experimental work had shown that the vitamin C content of the feed (usually pasture grass or green feed of some kind) increased the vitamin C content of the milk. More recent, carefully controlled work suggests that the vitamin C content of milk is but little affected, if at all, by feed.

Milk is a rather poor source of vitamin D, and it is very difficult to increase the amount of this factor through the use of natural feeds. Summer

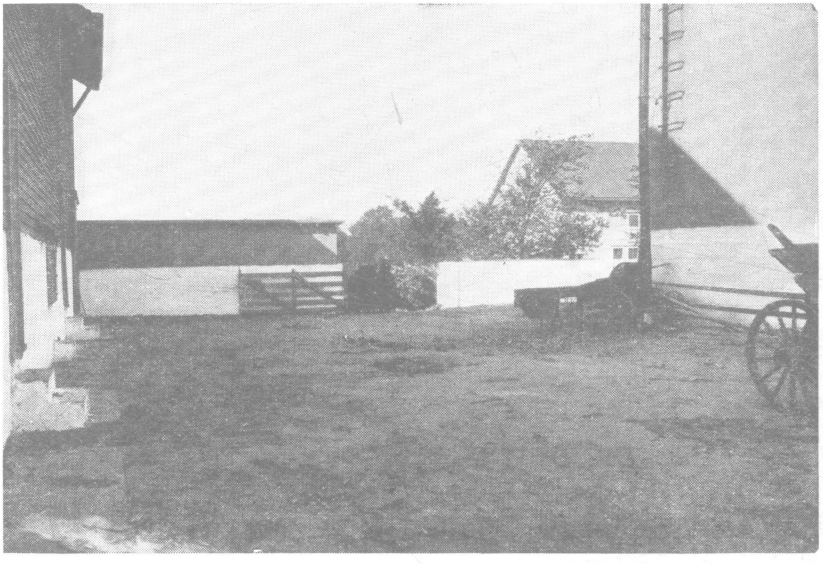

Fig. 1.—A concrete barnyard provides a clean, dry exercise lot the year round.

milk may be two or three times more potent in vitamin D than winter milk, but at best cow's milk will not prevent the development of rickets in children receiving milk as the sole source of vitamin D.

Milk contains only a small amount of vitamin E, but since this factor is widely distributed in natural foods its relative deficiency in milk does not present a serious problem.

Stages of Lactation and Gestation Affect Composition of Milk.—After a cow freshens, the fat test is high for a short period, after which it drops considerably. During the remainder of the lactation period there is a gradual increase in the percentage of fat, this being accompanied by a decrease in milk production. During the first six weeks of lactation the proteins and ash decrease and then remain fairly constant up to within two months of the end of lactation. During the last two months the proteins rise markedly

and the ash also increases. The sugar remains fairly constant until the last two months, at which time it may decline until the end of lactation.

Gestation influences the composition of milk only in so far as it affects lactation.

Effect of Bacteria on Milk

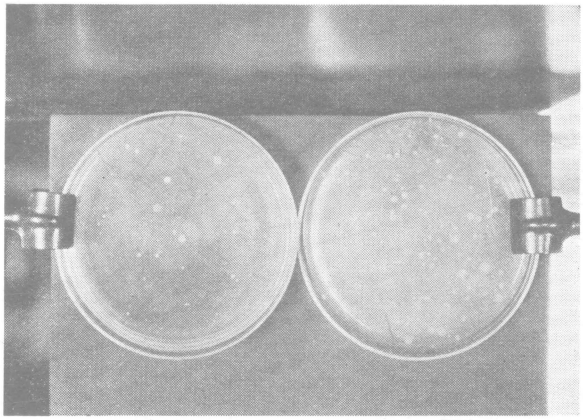

Fig. 2.—The bacteria in milk when grown on a nutrient media in the laboratory form colonies which appear as white spots as shown on the above plates. In making a bacterial count each colony is counted as a single organism.

Bacteria are often spoken of as both friends and foes of the dairy industry. The presence of certain types of bacteria is necessary in making butter, cheese, and other milk products where desirable changes are brought about by their growth. On the other hand, there are types of bacteria which, when present in milk, may cause disease among those who consume the milk or milk products. Still other kinds of undesirable bacteria are those which cause bad flavors and odors to develop in milk.

In the field of market milk all bacteria are undesirable, since it is due to their presence that milk sours, becomes offensive in odor and taste, and may be the cause of sickness and death. In general, milk containing the smallest number of bacteria, none of which are harmful, is the best milk.

Acidity

Milk is a very perishable food. It is therefore highly desirable to give it to the consumer in a condition that will guarantee maximum keeping power. One of the best guides for this is acidity. This has led to the adoption of certain standards as to the limit of acidity that will be tolerated at the receiving plant. When milk is rejected at the receiving platform because of high acidity, it indicates that the milk was improperly handled after it was drawn.

Flavor, Odor, and Color

Milk has a characteristic flavor and odor. Sometimes, due to faulty methods of production and processing, abnormal flavors appear. Fortunately, the flavor of milk can be controlled. It is of utmost importance that every effort be made to preserve the normal condition if consumption is to be maintained. Color also affects the salability of milk. This can be controlled, to a certain extent, by feeding. This will be more fully discussed under the head, Practical Methods of Producing Quality Milk, page 10.

Effect of Processing on the Value of Milk

Pasteurization.—Much controversy has been aroused over the effect of pasteurization on the nutritive properties of milk. The following quotation is taken from Fundamentals of Dairy Science, 2d edition, by Associates of L. A. Rogers, one of the most recent and authoritative sources of information.

"A great deal of work has been done on the effects of heat on the chemical and nutritive properties of milk . . . There is very satisfactory agreement that pasteurization, as ordinarily practiced, has only a small effect on such physical and chemical properties of milk as have so far been studied. . . . There is a satisfactory agreement that pasteurization has no deleterious effect on vitamins A and B, but has a decided tendency to destroy vitamin C.

"Some . . . recent results indicate that fresh or rapidly boiled milk is superior in its nutritive qualities to pasteurized milk, and that this superiority cannot be wholly explained as due to the tendency of extended heating to destroy the anti-scorbutic vitamin in milk. But the results in question are so much in conflict with each other on certain important points that the interpretation of their practical significance must be postponed until more work has been done in the field.

"In considering the practical conclusions to be drawn from the work which has just been discussed, it must be remembered that it is not usually wise to use milk as the sole article of diet, even for very young animals. The specialists in infant feeding recommend that babies have a small amount of orange juice as a part of their diet from the first few days of life onward, even when they are nursed by their mothers, and the same recommendation applies with still more force to babies who do not receive their mother's milk.

"Most of the experiments where raw and heated milk have been fed along with other articles of diet have failed to show any superiority of the former, and general practical experience seems to be in harmony with this outcome of the experiments. There can be little question, therefore, that the dangers which are known to be avoided by pasteurization should receive more consideration than the rather questionable points of superiority of raw milk. Until infectious diseases are under much more complete control than at present, it will be wise for our larger communities to hold to and perhaps even extend the practice of pasteurization."

Powdering.—Powdered whole milk is milk from which practically all the water has been removed. Since the resulting product contains everything that was in the original milk except possibly vitamin C, its nutritive value is very similar to that of liquid whole milk.

Powdered skimmilk is similar to powdered whole milk except that the fat is lacking, thus reducing the nutritive value of the product to the extent of the nutritive value of the fat. This means that skimmilk powder is lacking in the fat-soluble vitamins and deficient in vitamin C.

Condensing.—Sweetened condensed milk is milk from which about three-fifths of the water has been removed and about 15 per cent of cane sugar added. This product has been found to have the same vitamin A, B, and C content as whole milk.

Evaporating.—Evaporated milk is whole milk which has been deprived of about one-half of its water. It contains, therefore, all the constituents of the original milk, except water, in the original proportions. This product is similar to whole milk, in vitamin content.

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Practical Methods of Producing Quality Milk

Efficient cattle housed in clean, comfortable surroundings are the first essentials of quality milk production. It is necessary also that the milk be handled in clean utensils and be properly cooled to preserve the original quality of the milk.

Selection of Cows on the Basis of Production

Although expensive equipment is not essential in producing quality milk, the man with inefficient cattle will usually be unable to provide the necessary minimum of dairy facilities. As stated previously, milk from cows within the same breed varies in fat percentage. Since most farmers either sell milk on test or sell butterfat, it is necessary for the dairyman to know how much each cow produces in terms of milk and fat. Therefore, he should keep production records and cull and breed his herd in the light of this information.

Whether cattle are bred or purchased, the dairyman should know the producing ability of each cow. Every effort should be made to maintain disease-free dairy herds. Diseased cattle are never as efficient as healthy cattle.

Maintenance of Disease-Free Herds

All cattle producing milk for human consumption should be free from infectious diseases. If disease is present, it may be carried to the milk and then infect consumers. In cases where the udder is involved, the infection in milk will be high. In other cases where the organism is expelled with the feces there is always a chance of infecting the milk.

Tuberculosis.—The most dangerous disease common in this country which may be carried from cow to man is tuberculosis. Ohio became a tuberculosis accredited free area in January, 1931, and 42 other states have already become accredited. Thus the possibility of carrying this disease in milk is being eliminated. Dairymen should continue to cooperate with state and federal officials in the testing of cattle for this dread disease.

Contagious Abortion.—During recent years many studies have been made concerning the relation between contagious abortion in cattle and undulant fever in human beings. Apparently the characteristic infection of the cow is much less virulent to man than the abortion organisms common to goats and swine. Since any of these, however, may infect the cow, milk sold in the raw state should come from cattle tested and found free from this disease. This not only safeguards the purchaser of milk but also the farmer's own family. Up to July 1, 1936, over 400,000 cattle in Ohio were tested for this disease and the reactors eliminated. This source of infection is also being brought under control. All dairymen should work to eliminate this disease.

Garget, Mastitis or Mammitis.—These terms are used to indicate disease of the mammary glands, and for practical purposes may be considered synonymous. There is an acute type of mastitis in which the udder shows acute inflammation, and the cow seems to suffer extreme pain and often goes down. It is not uncommon for this type of infection to be fatal.

Another type of mastitis produces septic sore throat in humans. The origin of this infection is the respiratory organs of milkers and handlers of the cattle. This infection seldom produces severe symptoms in cattle. Fortunately, it does not occur often. However, it is serious enough when it does occur, so that any evidence of this infection should be cause for real effort to locate the source of the infection. This organism is killed by proper pasteurization. Unfortunately, the disease may be spread by handlers of the milk after it leaves the farm or the processing plant. Thus it is necessary that people handling milk, as well as the cattle producing it, should be healthy.

The majority of cases of mastitis are chronic and are caused by a long chain streptococcus organism. The infective material usually enters the udder through the teat canal. Open injuries of the teat or udder may provide a site of bacterial invasion and result in udder disease. The losses to the dairy industry caused by this disease are enormous, probably greater than those from tuberculosis or Bang's disease. Losses are incurred through the destruction of milk secreting tissue in the udder, resulting in decreased efficiency in milk production, and also through changes produced in the milk which render it undesirable for human consumption. These changes, which occur in the milk as a result of the disease process, furnish means for detecting the obscure cases of a chronic nature.

The following table shows the nature and extent of the changes which we expect to encounter in an examination of milk from a diseased udder. These changes may not all be apparent in the same sample; therefore, in testing for this disease more than one test should be employed. For instance, the first few streams of milk from an infected quarter will not always show flakes or clots when drawn on a fine mesh screen, yet the same sample may react to the brom thymol blue test indicating disease.

TABLE 4.—*The Effect of Udder Disease on the Milk*

	Normal Milk	Milk from Diseased Udder
Physical	No flakes or clots present	Flakes or clots present
Ph	6.3 — 6.7	6.9 or above
Leucocytes	Less than 500,000 per cc.	Over 500,000 per cc.
Bacteria	Low number, no streptococci	Number increased, streptococci present
Lactose	Usually over 4 per cent	Decreased, less than 4 per cent
Chlorides	Usually less than 0.15 per cent	Increased, 0.15 per cent or over
Fat	.....	Variable, usually decreased
Protein	.....	Albumin usually increased
Catalase	.....	Increased
Curd tension	.....	Decreased

The control measures for this disease are fundamentally similar to those employed for the control of Bang's disease or tuberculosis. That is, the measures consist of a test or series of tests to detect the existence of the disease, and the practice of sanitary measures to prevent the spread. We do not resort to a system of treatment to effect a cure. The sanitary measures employed should consist of a system of segregation or isolation of infected animals, and the strict practice of hygienic principles to reduce the spread of the disease. The existence of mastitis in the herd should not be taken lightly.

One practical way of diagnosing this disease is to use a strip cup (a small receptacle covered with a 100-mesh screen or a fine black cloth). If the first few streams of milk from each quarter are milked into such a cup, flakes will be observed when they first appear; otherwise the infection may go unnoticed until it is far advanced and possibly has been the cause of great spread of the disease. Incidentally, the use of the strip cup will tend to lower the bacteria count in the milk, since the first few streams carry relatively large numbers of organisms.

Regular brom thymol blue tests may be used to supplement the strip cup in diagnosing mastitis. To make this test, milk 5 cubic centimeters into a test tube. Then add from ½ to 1 cubic centimeter (depending on strength of solution) of brom thymol blue. If the milk is normal (slightly acid), the mixture will have a greenish-yellow color; if abnormal (neutral or alkaline), it will turn green or blue. Each quarter should be tested separately, because often only one quarter is involved. Mixing the milk of the four quarters would dilute the milk of the infected quarter and make the test less sensitive. Then, too, this would not locate the infected quarter.

The test tubes and brom thymol blue used in making these tests may be secured from dairy supply houses or from some druggists.

Some feel that the frequent milking of infected udders before the infection is deep seated will sometimes effect a cure. Some carry out this plan by placing the infected cow in a boxstall with enough calves to keep the udder

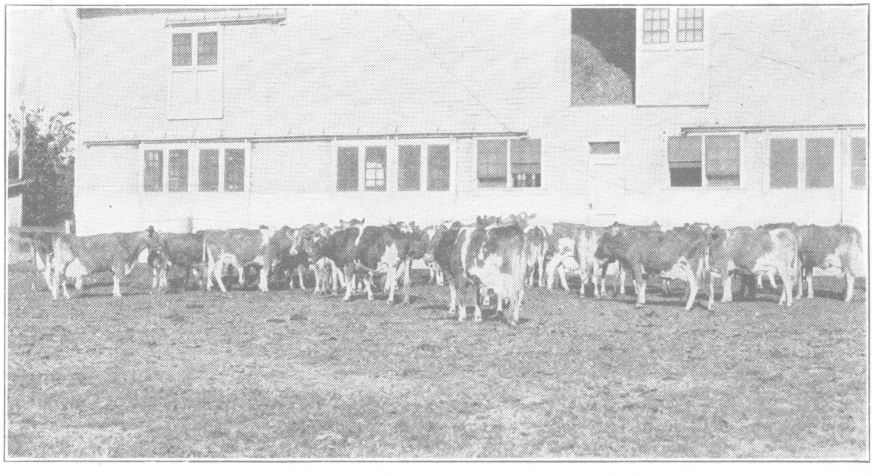

Fig. 3.—The first essential of quality milk—clean, healthy cows.

constantly milked out. The BEST way to deal with this disease is to avoid it. Prevent injuries to udders, so far as possible; this can be done by furnishing roomy, comfortable stalls kept well bedded. Eliminate drafts. Close doors or windows which expose cattle unduly. Milk diseased cows after the healthy ones. Wash your hands carefully after milking diseased animals. Never allow milk from a diseased udder to get on the floor of the stable. Keep cows suffering from mastitis together at one end of the stanchion row.

Other Diseases.—Any abnormal or unusual condition should be closely observed and any extreme condition should be sufficient cause to discard the milk until the affected animal appears normal.

Dairy farmers should be on the lookout for diseases or epidemics spread by milk, and should be ready at all times to call a veterinarian or to assist authorities in locating the source of infection. The important fact to bear in mind is that milk-borne epidemics can be prevented.

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Care of Cows at Calving Time

One of the most important management problems is the care of cows at calving time. Dairy cows should be dry for from six to eight weeks, and should be liberally fed so as to be in good condition at freshening. Laxative rations such as two parts each of oats and bran and one part of oil meal are very satisfactory a few days before and after calving.

A week or so before calving, the dry cow should be placed in a well lighted, comfortable box stall. This stall should be so built that it can be readily cleaned and disinfected. It should be thoroughly cleaned and disinfected after each cow has been removed.

A good way to avoid difficulty at parturition is to be on hand to give assistance when necessary. If abnormal conditions occur which require a veterinarian, no time should be lost in getting this assistance.

Careful attention should be given to the udder. It should be evened up after the calf has nursed, but it is better not to milk out completely for two or three days. A good massage several times a day will often help in reducing excessive swelling.

Four or five days after calving, the cow may, if she appears normal, be returned to the milking herd.

Floors under the milking herd should be kept clean, as damp or dirty floors often become a source of udder infection. Milk from bad quarters should always be milked into receptacles and never on to the floor.

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Feeds and Feeding

While it is true that it is practically impossible to change the chemical composition of milk through feeding, it is interesting to note that those feeds which are most desirable from the standpoint of the health and efficiency of the cow tend to produce milk of superior quality. Thus the recommendations for feeding for *quality* milk production are exactly in line with those made for *efficient* milk production.

Pasture

The natural feed for the cow is pasture grass; there is nothing superior to it for dairy cattle. Its desirable effect on the vitamin content of milk has been discussed. Green grass also increases the yellow color in milk. The milk of cows on pasture often contains three times as much color as milk of cows fed hay and silage.

Pastures of alfalfa or clover impart flavors to milk, so it may be desirable to remove cattle from such pastures as long before milking as possible. Often, when cattle go to pasture, the milk takes on a decided flavor; this may be due to the abrupt change from dry feed to pasture. It is always good management to make the change from dry feed to pasture as gradual as possible. Give the cows a good feed before they are turned out the first day and allow them on pasture only two or three hours. Gradually increase the time on pasture, so that at the end of three or four days they are fully adjusted to pasture feeding.

Hay*

Legumes make the most desirable hays for dairy cattle. If these are cut at the proper time and made under good weather conditions they will carry most of their leaves and will show a good green color when harvested. Hays of such character are rich in digestible nutrients and tend to increase the yellow color of milk.

Clover should be cut when it comes into full bloom. Detailed information on the cutting, curing, and storing of alfalfa hay may be found in Extension Bulletin 137, Alfalfa in Ohio Farming. For the growing and harvesting of soybeans for hay, see Extension Bulletin 151, Sudan Grass, Soybeans, and Other Emergency Hay and Pasture Crops.

When sweet clover hay is fed in conjunction with other roughages, or as the sole roughage, it sometimes produces a condition resulting in internal hemorrhages. This apparently is due to damage resulting from the action of bacteria or molds. Undamaged hay does not cause this condition. If unusual swellings occur in animals fed sweet clover, immediately substitute some other roughage and communicate with the College of Veterinary Medicine, Columbus, Ohio.

The feeding of hay raises more or less dust, and some of this is likely to find its way into the milk, and thus contaminate it. Most hays, and especially hay made from legumes, impart some flavor to the milk. Damaged hay imparts a musty odor to the milk if fed one or two hours before milking.

Hay fed five hours previous to milking seems to have no effect on the flavor or odor of milk. Flavors from hay may be eliminated by feeding after milking and not immediately before.

Silage

Corn.—Corn silage is an excellent feed for dairy cattle. It imparts a distinct flavor or odor to the milk if fed one or two hours before milking.

* "When" and "How" in Haymaking, Extension Bulletin 160, The Ohio State University.

This can be avoided by feeding silage after milking, or at least five hours before milking.

Legumes.—Realizing that much of the carotene (yellow color) in green crops is lost in the curing process, attempts have recently been made to prevent this loss by putting the crop into silos. Alfalfa and soybeans lend themselves to this procedure. Good results have been obtained by ensiling the green crop without any special treatment, and by adding molasses or mineral acids to the material as it goes into the silo.* The mineral acid treatment (A. I. V.) has thus far given most consistent results with respect to carotene preservation. The following tables demonstrate the marked effect upon the carotene content of butterfat and hence upon the color of milk produced during the winter by feeding A. I. V. alfalfa-clover silage:

TABLE 5.—*Carotene Concentration in Butterfat Produced by Cows Fed all Hay or all A. I. V. Continuously (Mg. per Kg.)*

Cows and Breed	Oct. 15	After 30 Days	After 63 Days	After 120 Days	After 150 Days
ALL HAY					
Holstein 352	3.20	2.29	2.28	2.66	1.70
Holstein 442	4.60	2.28	1.80	3.12	2.01
Jersey 385	11.60	3.65	4.46	Dry	Dry
Jersey 398	12.20	3.24	2.58	3.46	3.22
ALL A. I. V.					
Holstein 386	4.35	6.27	6.50	9.60	7.30
Holstein 430	3.40	6.20	6.85	7.55	4.96
Jersey 393	5.12	6.94	6.65	3.34(?)	Dry
Jersey 477	10.08	9.97	8.20	10.05	6.86

TABLE 6.—*Carotene Concentration in Butterfat Produced by Cows Fed Hay and Corn Silage or A. I. V. and Corn Silage and Reversed (Mg. per Kg.)*

Cow and Breed	Oct. 15	End of First Period HAY	End of Second Period A. I. V.
Holstein 346	3.08	3.14	7.48
Holstein 465	2.12	2.57	5.44
Jersey 437	4.32	2.02	11.75
Jersey 453	1.59	3.26	7.44
		A. I. V.	HAY
Holstein 343	4.84	6.05	3.04
Holstein 476	...	5.85	2.74
Jersey 373	3.22	8.60	2.12
Jersey 435	4.52	8.05	4.32

* For details of these methods communicate with the Dairy Department at the Ohio Experiment Station, Wooster, Ohio.

The amount of carotene passing into the milk fat will depend upon the amount of carotene fed and upon the breed of the cow, as well as upon the individual animal. Guernseys and Jerseys will transfer proportionately more carotene to their milk than will Holsteins and Ayrshires.

Miscellaneous Feeds

Cabbage, Rape, and Kale.—These impart characteristic flavors and for that reason, if fed, should be given as long before milking as possible. These are not common feeds for dairy cattle, and certainly no special effort should be made to supply them.

Turnips.—Turnips are an excellent feed for dairy cattle, but they impart a decided flavor to milk if fed just before milking. However, 40 pounds of turnips fed to a cow five or six hours before milking, produced no flavor in the milk. Obviously these feeds should be fed at least five or six hours prior to milking.

Concentrates.—The common concentrated feeds have relatively little influence on the flavor and odor of milk. However, certain feeds such as linseed oil meal, peanut meal, and gluten products have a tendency to produce a soft butter of inferior flavor, while cottonseed meal renders the butter hard and tallowy. These feeds produce no marked effect except when fed in excessive amounts. Ground soybeans, when fed at the rate of 2½ pounds per head daily, have little or no influence on the flavor of milk, but may produce butter with a gummy consistency. Concentrates are usually fed before or during milking. This is a safe practice.

Obnoxious Weeds and Poisonous Plants

Weeds.—Weeds, particularly those causing undesirable flavors, should be eradicated. The greatest difficulty with weeds occurs in poor, wornout pastures. One of the ways to eliminate this difficulty is to fertilize and build up the pastures. Pastures furnishing plenty of feed are much less likely to cause trouble than poor ones, because cattle seldom eat highly flavored feed when plenty of good feed is available. Wherever possible, it is well to cut the weeds at least once a year.

Probably the worst offender in causing bad flavor in milk is the wild onion. Ragweed is another undesirable weed which affects the flavor of milk.

In cases of bad infestation with weeds such as wild garlic it may be necessary to allow the cattle on infested areas for only two or three hours after milking, removing them then to the barn or some uninfested pasture.

Poisonous Plants.—A number of plants and weeds may poison cattle, and in some cases these poisons are imparted to the milk, producing symptoms in the consumer similar to those noted in the cow. Experience indicates that poisoning is sometimes caused by St. Johnswort, sorghum, and Sudan grass.

One of the most common places to find poisonous plants is in fencerows. The wild cherry is usually found here. Professor Hansen of Purdue University from a study of 300 farms found that 20 per cent of the deaths due to poisoning were caused by wild cherry. When trees are cut off and new

sprouts come up from the stump the cattle eat these with fatal results. When animals graze on wilted wild cherry leaves they may be fatally poisoned.

The black locust is another cause of poisoning. The poison, robinin, has been isolated from the bark and is apparently the cause of the difficulty. The honey locust, though more formidable in appearance, is harmless.

Poison ivy, which is often found along fence rows, has no toxic effect upon the cow.

Water hemlock is another plant which is poisonous. It is often eaten in the spring. The young sprouts are very succulent and palatable.

Probably the most important of the woodland species causing poisoning is the white snakeroot. Professor Hansen states that the evidence is overwhelming that the disease in humans known as milk sickness is caused by drinking milk from animals that have eaten white snakeroot.

There are some other wild plants which produce poisoning, but which are relatively unimportant.

Water

Dairy cattle should have a good wholesome supply of water the year round. Drinking cups or an accessible water tank should be provided. Cattle should not be allowed at any time of the year to wade around in muddy stagnant pools or contaminated streams. Such conditions make clean milk production almost impossible and often lead to diseased udders. If cattle secure water from brooks or springs while on pasture, they should be free of contamination.

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Housing the Dairy Herd

The Barn

Arrangement.—Dairy cattle should be comfortably housed in quarters that are easily cleaned. There should be plenty of room for the cattle and they should be so arranged that the attendants can readily work about them. Some dairymen prefer to face the cattle out so that a wagon can be used to clean out the barn. In this way, manure can be taken to the field with a minimum of labor. The disadvantage of this system is that most farmers make no other provision for cleaning out the barn, so that it is always necessary to hitch up a team regardless of the weather or the condition of the roads and fields. Under such conditions the barn may not be cleaned as often as necessary.

Another disadvantage is that there is less light back of the cattle with such an arrangement. Inasmuch as most of the work, including the milking, is done at the rear of the cows, many feel that facing cattle in is much to be preferred. This avoids bringing a wagon with its attendant dirt or mud into the barn, and furnishes light where light is most needed.

There is some evidence that the operations of feeding, milking, and cleaning out can be done with less steps in a barn where the cows are in rows running lengthwise of the barn and facing in. Dairymen building new barns

or repairing old ones should study the matter of arrangement with a view to producing quality milk with a minimum of steps.

Covered Barnyards or Straw Sheds.—Many dairymen keep their cattle in covered barnyards except during milking. If this system is followed, the yard should be cleaned out regularly and kept well bedded. Too often covered barnyards are not properly cleaned and bedded, so cattle are not kept sufficiently clean to produce quality milk.

Great care should be exercised in avoiding drafts in covered yards, for cattle in drafty covered yards are more uncomfortable than they would even be outdoors, and hence are more likely to get out of condition.

Light.—Light is obviously necessary in dairy farms where cleanliness is absolutely essential. Some milk ordinances call for 4 square feet of window

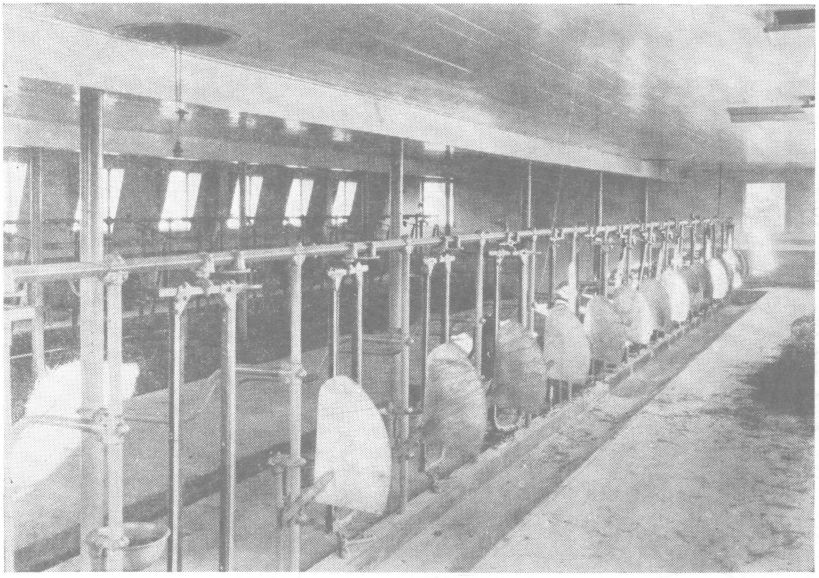

Fig. 4.—A raised feeding floor with a smooth surface saves time in feeding and cleaning.

glass per stanchion. This may be desirable, but the important thing is to have plenty of light properly distributed. Windows, of course, must not only be properly placed but kept clean.

In view of the fact that much of the work is done in the dairy barn before it is light in the morning and after dark in the evening, at least during half of the year, it is just as essential to have adequate facilities for artificial lighting as it is to have well placed windows kept clean.

Ventilation.—Good ventilation in the dairy barn is an absolute essential. Cattle must have pure fresh air in order to keep healthy and efficient, and the dairy barn should be kept reasonably free from odors to avoid tainting the milk.

Ventilation may be furnished in most barns without great expense. However, there are certain principles which must be recognized in building a

ventilating system. Those contemplating the building of new barns or the repairing of old ones should make a thorough study of this important point. The Agricultural Engineering Department of Ohio State University will be glad to help with information and suggestions.

Walls and Ceilings.—The walls of the dairy barn should be sealed smooth on the inside with a minimum of ledges and places for dirt to accumulate. If the barn is made of lumber, the foundation should extend up the wall at least a foot, and the foundation wall and the sheathing should be flush. The sheathing may be painted, preferably white or a light color, so that it can be readily washed. Otherwise the walls should be whitewashed often enough to give a clean, bright appearance. If the barn is constructed of concrete, brick, or tile, the walls should be smooth and easily cleaned.

The ceiling should be high enough to furnish comfortable head room, but should not be so high as to interfere with ventilation. Ceilings about 8 feet high are satisfactory. The ceiling should be tight to prevent the dropping of dust and chaff, when hay or straw is stored above.

Anything which tends to keep down dust or the accumulation of dirt makes it that much easier to produce milk free of foreign matter and with a low bacterial content.

Stalls.—The stalls for dairy cattle should be wide enough to prevent one cow from stepping on the udder or teats of another. They should be long enough to give the cow room to stand without stepping back in the gutter. However, they should be short enough so that the manure will usually fall in the gutter and not accumulate on the end of the stall platform. The following dimensions are suggested:

TABLE 7.—*Size of Stalls for Various Breeds*

	Minimum width	Minimum length	Maximum length
Jerseys	3 feet 6 in.	4 feet	4 feet 6 in.
Guernseys	3 feet 8 in.	4 feet 4 in.	4 feet 10 in.
Ayrshires	3 feet 8 in.	4 feet 4 in.	4 feet 10 in.
Brown Swiss	4 feet	4 feet 10 in.	5 feet 4 in.
Holsteins	4 feet	4 feet 10 in.	5 feet 4 in.

As a practical matter, it is often well to have one row of stalls which vary in length. This can easily be done by running the back of these stalls at an angle to the barn wall. For example, one might well have a row of stalls varying from 4 feet to 4 feet 6 inches in length. (Table 7 gives minimum widths for stalls.)

It is well to have a depression in the front of the stall floor an inch deep extending back from the manger for 15 or 18 inches; this helps to hold the bedding forward. From the depression back, there should be a slope of an inch to help keep the stall floor dry. The floors of the stalls, if made of concrete, should be left rough (finished with a wooden float) to prevent slipping. All material used for stall floors should be impervious, easily cleaned and washed, and not slippery.

Mangers.—Mangers should be about 2 feet wide. They should be finished with a smooth surface and if possible slope to a drain. The bottom of the manger should be curved rather than flat, thus leaving no corners in which spoiled feed may accumulate. Mangers of the type suggested can be readily swept or washed.

Feeding Alley.—A very practical arrangement is to have a raised feeding floor which acts as a front to the manger. The feeding floor, in any event, should be finished with a smooth surface. This facilitates the sliding of hay in feeding and also makes cleaning much easier. The alley should be wide enough to facilitate feeding.

Gutters.—The gutter back of the cows should be at least 8 inches deep at the end of the stalls and 6 inches deep on the side toward the walk and should be 14 to 16 inches wide. Gutters should be finished with a smooth surface, and slope toward a drain which may be opened when the barn is washed.

Walks.—If the cattle are faced in, the walk between the gutter and the barn wall should be at least 5 feet wide; a walk 6 or 7 feet wide is even better. Wide walks prevent spattering of the barn walls with urine and manure and furnish more room to move the cattle in the barn.

If two rows of cattle are faced out, the walk between the cows should be at least 8 feet wide and, like all other cattle walks, should be finished rough to prevent slipping.

Box Stalls and Calf Pens.—Enough box stalls should be provided to care for maternity cases and for cows that are injured or for any reason cannot stand in a stanchion. These stalls should have impervious floors and be so arranged that they can be readily cleaned and disinfected. Box stalls made by wooden slats with many cracks and crevices cannot be recommended.

Calf pens, like other pens, should be so made as to be easily cleaned and disinfected.

Yards and Exercise Lots

Dairy cattle should be turned out for exercise each day when not on pasture. There is nothing better than a good, clean, well drained yard for this purpose. This yard should be so located as to be protected from the prevailing wind. In times of extreme cold or storm or when the yard is excessively muddy, the cattle should be kept in. Provision should be made for a barnyard that is usable at all times.

Manure Disposal

There should be litter carriers or other provision for the cleaning out of the dairy barn. The manure should be removed at least twice a day and more often where cattle are fed and milked oftener than twice a day. The manure should be removed far enough so as not to be a source of contamination of lots, or should be put in a tight manure pit. It is desirable to remove the manure immediately to the fields when possible, and also have a manure

pit to take care of manure which for some reason or other cannot be taken immediately to the fields.

The big problem in the control of breeding places for flies is the removal of manure. If manure cannot be removed directly to the fields as suggested above it should be stored in a screened shed or on a concrete surface. Since it is often impossible to remove all the breeding places, it becomes necessary in some cases to treat the breeding place—manure pile or whatever it may be—with something that will kill the larvae or maggots.

Powdered borax sifted evenly over the manure pile at the rate of 1 pound of borax for every 16 cubic feet of manure will give good results.

Fig. 5.—When manure is disposed of in this manner the cows cannot wade through it and the breeding of flies is greatly reduced.

Other Livestock in the Dairy Barn

Chickens or swine should never be allowed in dairy barns. If other classes of livestock, such as horses and sheep, are housed with the dairy cattle there should be a reasonable space between the dairy section and that devoted to other animals, or better, a tight partition should be made to separate the other animals from the dairy cattle.

Grooming the Cattle

Cleaning.—All dairy cows should be thoroughly curried and brushed at least once a day. This makes it easy for the milker to make the final preparation for milking and helps insure clean milk. If a cow gets unusually dirty on the flanks, she may be washed. However, very little washing is actually necessary when cattle are properly housed and regularly curried and

brushed. The tails should be washed often enough to prevent any accumulation of matted dirt. Dirty tails help to make dirty cows.

Very little clipping needs to be done on cattle properly handled. In the winter it may be well to clip the udder and flanks, as it is usually easier to wipe such cattle clean.

Keeping cattle clean not only makes for clean milk production but also makes for more efficient production. Well groomed and fed cattle are seldom greatly troubled with parasites, such as lice. So here again, clean milk producing methods and efficient production go hand in hand.

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Milking--Care of the Milk

Ordinarily, a normal healthy cow that is fed good clean feed will produce clean milk with a good flavor. Although milk is seldom, if ever, bacteria-free when it is drawn from the udder, the organisms found in milk carefully drawn are of little importance; that is, they play little or no part in the ultimate spoilage of the product. The average number of bacteria which find their way into the milk from the interior of the cow's udder is about 500 per cubic centimeter, and their importance lies only in the fact that they contribute to the final number of organisms present. Occasionally, an individual cow is found that produces milk with an exceptionally high bacterial count. A cow producing milk with as high as 177,000 bacteria per cubic centimeter, with an average of 102,000, was studied at the University. Such a cow has no place in the herd where the aim is to produce milk of high quality and low bacterial count. Fortunately, such individuals are few and far between.

Provided the cow is a healthy, normal individual, the conditions to which the milk is subjected after it leaves the udder determine its quality. Dangers lurk at every step of the process, and often it is the seemingly insignificant details that cause the trouble. It does not require expensive equipment, high priced cows, or much extra work to produce clean milk with a low bacterial count. It is the careful attention given to every detail of the production process which determines the final quality of the product, and this can readily become a matter of routine.

Preparations for Milking

It is during the act of milking that the milk is exposed to its first contamination from the outside. Whether the milking is done by hand or by machine, certain precautions should be taken to eliminate excessive contamination. In the first place, the cows should be clean. Second, the flanks and udder should be wiped with a damp cloth. Once cleaned, the cow should not be permitted to lie down until after being milked. Third, the first few streams of milk should be discarded, as suggested previously. If the first few streams are milked on a cheesecloth or fine mesh wire strainer, diseased conditions of the udder can usually be detected by the presence of thick or ropy material which does not pass through readily. This practice is often very helpful in preventing the spread of garget or mastitis when a milking machine is used,

Hand Milking

The fact that he is producing a food product should be uppermost in the milker's mind, and he should conduct himself accordingly. He should wash his hands before beginning to milk; rinsing the hands with a weak disinfecting solution between each cow is commendable.

The practice of "wet" milking should not be tolerated. The importance of a small top pail cannot be overemphasized. The use of such pails eliminates from 40 to 70 per cent of the dirt and bacteria that otherwise might fall into the milk. Outer garments which the milker wears should be clean and should be worn only at milking time. The advantage of white garments for the milker is that they readily show dirt and therefore will be changed oftener.

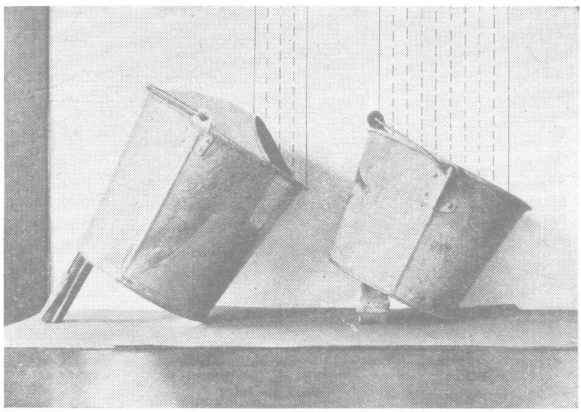

Fig. 6.—The covered top pail reduces the visible dirt in milk from 30 to 70 per cent.

Machine Milking

That an intelligent and well informed dairyman who is careful in his routine practices is able to produce milk of high quality with the use of milking machines, is shown by the fact that certified milk is being produced with them.

Certified milk is a very high grade of milk that must contain no more than 10,000 bacteria per cubic centimeter at the time of delivery to the consumer. Market milk of a good grade is also being produced in dairies where milking machines are used under ordinary conditions.

However, clean milk cannot be obtained by using neglected machines, and there is no short cut to cleanliness. The milking machine must be carefully washed and sterilized after each milking. The amount of visible dirt or sediment in machine drawn milk should be lower than in hand drawn milk because there is less opportunity for dirt to fall into it. However, where the dairyman is careless about letting the moist teat cups fall and come in contact with the bedding litter, milk free from visible dirt cannot be expected. Furthermore, in the stripping of the cow the same precautions should be taken as in complete hand milking. The number of bacteria and amount of visible dirt found in machine drawn milk are proportional to the care taken in washing, sterilizing, and operating the milking machine.

If unbalanced quarters and udder troubles are more common in a herd where the milk is machine drawn, this cannot be attributed entirely to defects

in the milking machine. For the most part, mistakes in operation rather than the defects of the machine are responsible for these difficulties. Poorly fitting teat cups or defective teat cup liners may cause no end of trouble. Cows should be quickly and thoroughly milked.

Most dairymen overlook the fact that cows in a low stage of production are not as completely milked as higher producing cows. There is no reason to believe that when proper precautions are employed in operating a milking machine there is more likelihood of udder troubles than when hand milking is practiced.

The Milk House*

Immediately after the milk is drawn from a cow it should be taken to the milk house or milk room. The necessity for a milk house or milk room separate from the stable arises from the fact milk absorbs odors very readily, and may go off flavor if allowed to remain in the stable any length of time. The practice of pouring the milk into the can or straining it in the stable not only exposes it to these undesirable odors but offers a good chance for bacterial contamination from dust in the stable air. Milk should, therefore, be promptly removed to a clean, airy room, free from dust, insects, and objectionable odors.

Fig. 7.—Every dairy farm should have a milk house where the milk can be strained, cooled, and stored. Note the rack for the cans and milk pails.

The milk room should not open directly into the stable. The stable air laden with dust and odors should have no chance to enter the place where milk is handled. Double doors or a protected passage should separate the barn and the milk house. Since prompt removal is desirable in order that the milk can be strained and cooled quickly without being subjected to the dust and odors of the stable air, the matter of milk house location should be carefully studied. The surroundings of the milk

* Plans and specifications for a milk house may be secured from the Agricultural Engineering department, The Ohio State University, Columbus, Ohio.

house should be such that the air will be free from odors and there should be nothing to harbor or attract flies.

The milk house should be conveniently arranged in order that the milk can be quickly and efficiently handled in a sanitary manner. The three processes which usually should take place in the milk room of the farm dairy where fluid milk is being produced are straining, cooling, and storing. The equipment necessary for the carrying out of these processes should be so arranged that the job can be done in the least time with a minimum amount of labor. Heavy lifting should be done away with so far as possible.

Furthermore, the arrangement should be such that the equipment can be easily washed and sterilized, and kept in a good sanitary condition between periods of use. A milk house with two rooms has great advantages over the one-room milk house. In the two-room milk house, one room can be used for handling the milk, while the other is used as a wash room and storage place for utensils and equipment.

On the farm where milk is bottled, a milk house should be provided with at least two rooms, and three are recommended. When three rooms are provided, one room is used exclusively for the handling of milk. In this room the milk is strained, cooled, bottled, and stored. Another room is used for the washing, sterilizing, and storing of equipment. The third room of the milk house should provide space for boiler, water pump, and refrigerating unit.

Straining the Milk

After milking, the milk should be taken to the milk house, strained, and cooled at once. The purpose of straining the milk is to remove the visible dirt. With careful straining through cotton filter pads, or discs, most of the dirt can be removed. However, the ideal way is to keep the dirt out of the milk rather than allow it to get into the milk and then try to remove it.

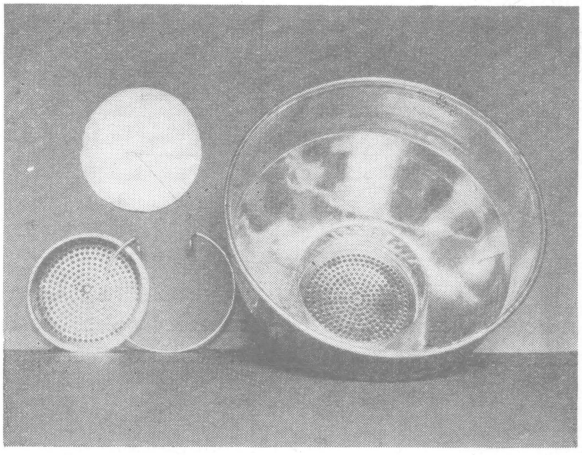

Fig. 8.—Strainers designed for the use of single service filter pads are best.

Milk that has been allowed to become heavily contaminated with dirt and is then cleaned by filtering or straining is not *high quality milk.*

The most satisfactory strainer is the type using a single service filter pad. The filter pads should be discarded after each milking. It is practically impossible to sterilize strainer cloths. Therefore, they have no place in quality milk production.

In all probability more milk is condemned due to the fact that it is not properly cooled than for any other one reason. The cooling of milk is done mainly for one purpose, to retard the growth of bacteria. Bacteria grow more rapidly in warm than in cool temperatures. Dr. M. J. Prucha of the Illinois Experiment Station made some tests to determine the temperature to which milk should be cooled. Samples of the same milk were held for 12 hours at varying temperatures. At the end of 12 hours, the number of bacteria in the different samples was determined. The results follow:

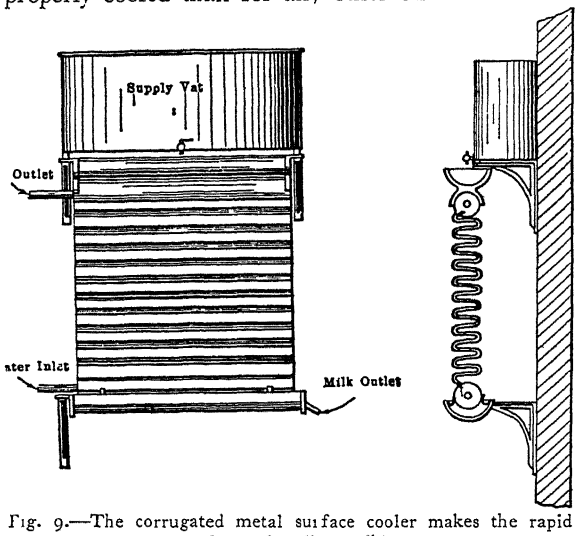

Fig. 9.—The corrugated metal surface cooler makes the rapid cooling of milk possible.

At 40 degrees F. there was no increase in bacteria.
" 50 " F. the increase was very slight.
" 60 " F. each bacterium produced 15 new ones.
" 70 " F. each bacterium produced 700 new ones.
" 80 " F. each bacterium produced 3,000 new ones.

We can readily conclude from the results of Dr. Prucha's experiment that milk of high quality, if not cooled below 60 degrees F. immediately after it is drawn, will not be of high quality at the end of 12 hours.

Today, when the larger cities are constantly reaching out farther and farther for their milk supply, cooling to a low temperature is becoming more and more essential, due to the length of time that the milk must spend in transit. The question of how milk may best be cooled naturally arises.

Methods of Cooling.—In general, the milk may be cooled in two different ways: first by the use of the surface cooler; and second, by placing the can of milk in a tank containing cold water. The surface cooler may have cold well water, spring water, or ice water pumped through it. The water in the cooling tank may be used just as it comes from its natural source, or may have ice added to it. A combination of the two methods is often used, the milk being first precooled over a surface cooler, then placed in a tank of cold water or even ice water and held until shipping time. Mechanical refrigeration is fast coming into favor among dairymen, and this process has many things in its favor.

Many dairymen make the mistake of trying to cool their milk by the use of cold air. A can of milk set out in the open air in winter, no matter

how cold the air, is not properly cooled. Another mistake consists in putting a can of warm milk in a refrigerator cabinet to cool. Air is a poor conductor of heat and the heat of the milk passes off slowly. Water has many times the heat conductive power of air. For this reason milk should be cooled by water even in the winter time.

Just what method will be used depends upon several factors. First of all, the temperature of the water which must act as the cooling medium must be considered. Milk cannot be cooled down more than to within two or three degrees of that of the cooling medium, no matter how careful the dairyman is in the process. Often the temperature of the natural water supply is too high. Tests showed that the average temperature of the cooling water used on 349 Ohio farms was 56.9°F. If the temperature of the water to be used for cooling is much over 57°F. then either ice or mechanical refrigeration should be used.

If ice is to be used, it will probably be most economical to precool the milk over a surface cooler, using the natural water supply as the cooling medium; then the milk (in cans) can be placed in a tank of ice-water. This provides cooling with the use of a minimum amount of ice.

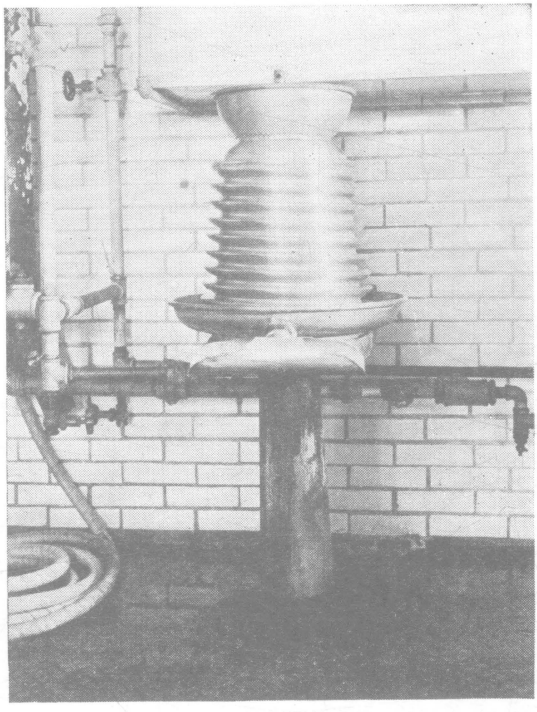

Fig. 10.—This type of cooler is very satisfactory in large dairies. Its construction makes it easily cleaned.

Another factor, which will determine to some extent the method of cooling, is the time which the milk is necessarily in transit. Milk that has to be transported a long distance in cans will have to be cooled to a lower temperature than milk that has only a short distance to go.

A very satisfactory method used by many dairymen is to precool the milk by the use of the surface cooler immediately after milking, after which the cans of milk are set in a concrete cooling tank containing cold water, and held until shipping time. Others strain their milk directly into the can, and as soon as the can is full it is placed in the cooling tank through which cold water is pumped. The milk in the cans should be stirred every few minutes to hasten the cooling process. Prof. E. H. Parfitt of Purdue University has

shown that stirring the milk while cooling greatly reduces the bacterial development during the storage period, and that the value of stirring is confined to the temperature reduction within the first hour.

Where mechanical refrigeration is used in connection with a surface cooler, the milk is generally cooled to a much lower temperature than that of the farm water supply. Obviously it would not be advisable to hold the milk in a cooling tank through which well water is pumped, since the milk would only be warmed by the water. The practice recommended in this case

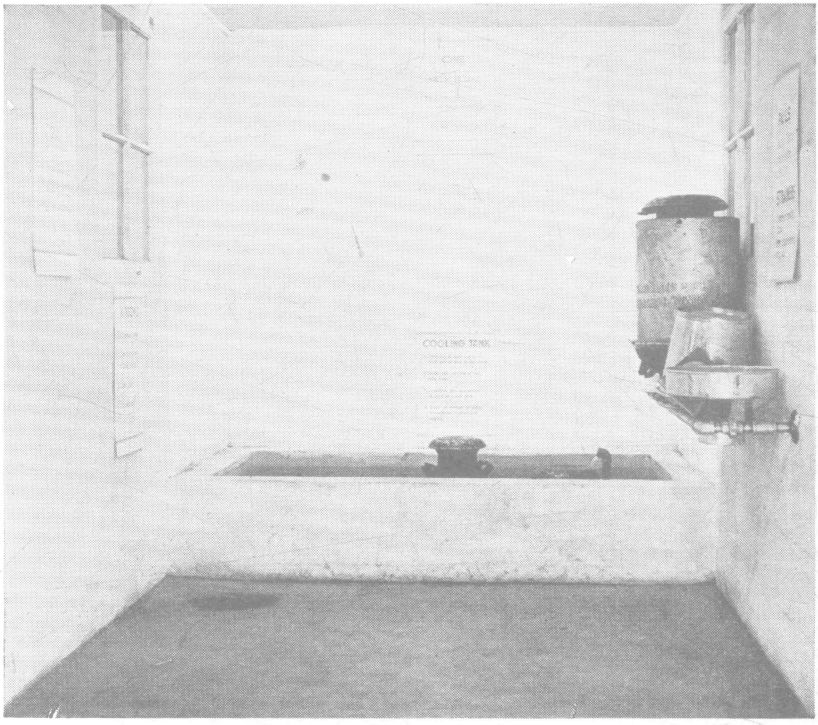

Fig. 11.—The concrete cooling and storage vat is the most common means of cooling milk on the farm. It is satisfactory only where a cold water supply is available. For most efficient cooling such vats should have a capacity of between 4 and 5 gallons for each gallon of milk cooled.

is to put the cans of milk in a well insulated dry box, which is as nearly airtight as possible.

Some prefer not to use a surface cooler with mechanical refrigeration. In such cases the cooling unit is placed in a refrigerator tank, filled with water. The milk is set in this water and thus satisfactorily cooled.

If a surface cooler is used, care must be taken to keep it scrupulously clean and sterile. Immediately after the milk is run over it, it should be rinsed with cold water and then scrubbed (using a brush) with hot water containing a dairy washing powder, then rinsed again with hot water or a hypoclorite

solution. Between milkings it should be protected from dust and flies. Just before using again it should be rinsed with hypochlorite disinfecting solution.

It is difficult to recommend any best way to cool milk. After all, it is not the method of cooling that counts, but the fact that the milk is cooled. In general, other things being equal, the lower the temperature to which the milk is cooled the higher its quality when delivered.

Bacterial Growth Rapid in Dirty Milk.—The rate of increase in numbers of bacteria is influenced not only by the temperature but also by quality of the milk. The multiplication of bacteria, on a percentage basis, is less in clean milk than in dirty milk. The effect of holding milk of different quality at different temperatures for the same length of time is shown in following table:

Table 5.—Bacterial Growth in Clean and Dirty Milk

Temp. of Holding	Bacteria per cc. when fresh	Bacteria after 12 hrs.
CLEAN MILK		
60 deg. F.	3,243	4,056
70 deg. F.	3,243	19,312
DIRTY MILK		
60 deg. F.	707,761	3,376,961
70 deg. F.	707,761	6,608,846

(Ayers, Cook & Clemmer, U.S.D.A. Bul. 642)

This table shows that there is a much more rapid increase of bacteria in dirty milk than in clean milk, stored at the same temperature.

Utensils and Equipment

Construction. — All utensils with which milk comes in contact should be constructed of an impervious, non-corrosive material. There should be no cracks, and all seams should be soldered flush and smooth. Utensils which are complicated in construction, making cleaning and sterilizing difficult, are impractical. Rusty or badly dented utensils should not be used for milk.

Utensils or equipment which are constructed of porous materials such as wood, are hard to clean; it is nearly impossible to remove all the milk solids. Such equipment provides suitable places for bacteria to multiply and are liable to become sour and foul smelling. Unbelievable numbers of bacteria may be added to the milk in this way.

Fig. 12.—The brush is indispensable in the cleaning of dairy utensils.

(Courtesy Texas A. & M. Col. & Exp. Sta.)

Some metals such as zinc, copper, and nickel are corroded by the organic acids in milk, and minute quantities of these metals give metallic flavors to the milk. Enough zinc may be dissolved from a galvanized utensil by sour milk to make it unfit for human consumption. Cracks and unsoldered seams are hard to keep clean and are often a source of many bacteria in milk.

Washing and Sterilizing Utensils and Equipment.—One of the most fertile sources of bacteria in milk is dirty utensils and equipment. Often when the milk shows a high bacterial count, if the utensils or equipment with which the milk comes in contact are examined, a yellow film will be found in or on them. This is a veritable hotbed of bacteria. Every piece of equipment and every utensil that milk touches needs special attention. Utensils may appear clean and yet add large numbers of bacteria to milk. The dairyman must go one step farther than thorough washing. *He must sterilize.*

To clean and sterilize dairy utensils, proceed as follows:

1. Rinse with clean cold water immediately after the utensil is used. This rinsing removes a large amount of the milk before it dries.

2. Wash in hot water containing a dairy washing powder. Soap is not satisfactory, as it leaves a film on the utensils. An inorganic powder, such as trisodium phosphate, washing soda, or good commercial dairy cleaner will be satisfactory. Use a brush in washing. A properly constructed brush will reach the corners and creases much better than a cloth. After the brush is used it can be rinsed in clean water and then laid in a sunny, airy place to dry. A wash cloth for dairy utensils should not be used because of its unsanitary nature.

3. Rinse with clean hot water.

4. Sterilize with steam, boiling water, or a hypochlorite solution.

In dairies where steam is available, the utensils should be placed in a steam chest, steamed, and left there until used again.

One advantage of steam or hot water as a sterilizing agent is, that after the sterilizing treatment the utensils and equipment soon dry. Bacteria do not multiply on dry surfaces and any bacteria which escape the action of the steam will not have a chance to multiply if the utensil is quickly dried.

Hypochlorite Disinfecting Solution.—The use of a hypochlorite disinfecting solution will not take the place of thorough washing. The first three steps in the cleaning process should be carried out as outlined above. After the final hot water rinse, the utensils should be allowed to drain dry and then be stored in a sanitary place. The best time to apply a hypochlorite solution is just before using. The disinfecting solution may be made up according to the directions accompanying any of the commercial preparations or from calcium hypochlorite (bleaching powder) and soda as follows:

Make a smooth watery paste of 12 ounces of commercial chloride of lime containing 30 per cent available chlorine (or 15 ounces of chloride of lime containing 24 per cent available chlorine), then add water slowly and stir thoroughly until the solution amounts to 1 gallon.

Dissolve 27 ounces of washing soda (use the common crystals, *not powder or cooking soda*) in 1 gallon of warm water. If chloride of lime containing 24 per cent available chlorine is used, it will require 34 ounces of washing soda.

Mix the two solutions, stir thoroughly, and let stand for several hours. Strain the clear liquid into a tightly closed glass bottle or jar and keep it in a cold dark room.

One pint of this stock solution should be added to every 8 gallons of water for the final rinse. These rinse solutions contain approximately 200 parts of available chlorine to 1,000,000 parts of water, which is the strength recommended for farm use.

Chlorine compounds in various forms and under numerous trade names are on the market. Their cost is usually more than the homemade solution, but some labor is saved in that no stock solution need be prepared, and their strength is usually more uniform.

Dairy utensils may be treated with chlorine solutions in two ways: (1) Immersing, and (2) spraying. Immersing the utensils in a tank containing the chlorine solution insures that the entire surface comes in contact with the chemical. Each utensil should be completely immersed and left for two minutes. The spray method may be used for large utensils.

It is especially adapted to treatment of coolers in which both water and brine flow. The sprayer should be of the pressure type, capable of covering considerable area with a fine spray.

It is essential that every particle of organic matter be removed before treatment with chlorine compounds, as milk, cream, or organic matter weakens the effect of the chlorine solution on bacteria. The solution should be applied immediately after completion of the washing process. Turn the utensils upside down in a clean, dry place free from dust and odors, and do not touch until needed.

Washing and Sterilizing the Milking Machine.—Because of the complicated construction of the milking machine, it needs special attention in cleaning and sterilizing. The following method of handling a milking machine as outlined by Prof. H. P. Davis of Nebraska has proven very satisfactory:

"Immediately after the last cow is milked, put the milking claw or the teat cups in a pail of warm (not hot) water and suck through the milk teat cups not less than five gallons of water. If warm water is not available cold will do fairly well. The sucking of this quantity of water may necessitate opening the pail and emptying the water so as not to get it too full. This drawing of warm or cold water through the rubber tubes rinses out the milk before it has had a chance to dry. It is better if this can be done in a wash room, but do it even if it is in the barn. The first rinsing completed, the milking units should be taken to the wash room, if they have not already been taken there.

"The rubber tubes and teat cups should be disconnected from the pail and placed in a wash tank or boiler of water at a temperature of not less than 175° F. nor more than 185° F. A metal rack can be set in a wash boiler to hold the rubber parts and prevent their being burned against the bottom. Care should be taken to see that the water gets into all parts of the rubber tubes; use long brushes for this purpose. After brushing, leave in the water for five minutes. The hot water acts like pasteurization to kill bacteria. Then thoroughly rinse and connect with one of the solution racks furnished

by milking machine companies. This rack has a bottle of weak chlorine solution that is adjusted so that the milk tubes and teat cups are filled with the chlorine solution and kept that way between milkings. Any of the common hypochlorite compounds can be used and the solution should be made up according to the recommendation of the manufacturer. Once a week the rubber parts should be taken apart and each part scrubbed with alkali after the preliminary rinsing and before the soaking in hot water. The careful following of this plan will keep the milking machine clean."

Storing Utensils.—Immediately after the utensils have been sterilized, if they do not remain in a steam chest as mentioned above, they should be stored in a clean airy place free from dust or flies, until the next time of use.

The effect of a good job of sterilizing is often lost due to the subsequent contamination by dust, flies, or careless handling.

The Significance of Quality

The production of good quality milk has tremendous significance. Unless milk of good quality is produced none of the products manufactured from it can be of the best grade. Since milk and its products are so important in human nutrition, and since quality may influence the amount of dairy products consumed, the production of clean wholesome milk is of universal interest.

While boards of health and milk regulations can, and have, played an important part in improving our milk supply, the most important factor in this industry is an awakened intelligent interest in milk production and processing, and this is a matter of education.

Individual farmers and cooperative groups alike should stimulate in every way education in this direction. Milk dealers and manufacturers should cooperate by paying for quality and refusing to handle inferior products.

The College of Agriculture and the Ohio Agricultural Experiment Station are interested in this problem from the standpoint of all concerned with milk, from producer to consumer, and will be glad to cooperate in advancing intelligent efforts to improve the milk supply and to increase the use of good dairy products.

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